CHAPTER 7.0: DATA GAPS AND RECOMMENDATIONS

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The analysis team identified several recommendations for future work that would provide better confidence in our understanding of water quantity and quality in the Nisqually watershed. Recommendations are discussed in detail below. The first four recommendations are likely the highest priority in that they will either improve the confidence in results or will improve the ability to assess water quantity situations in the future. The authors also noted that increased confidence would be gained for subbasins of interest if the flows in the main stream of each subbasin were separated from the flows of the smaller tributaries flowing directly into the mainstem Nisqually. We recommend this be done in the future where water use and flows are evaluated in greater depth.

TOP PRIORITY RECOMMENDATIONS

The following recommendations reflect the areas of uncertainty that have the greatest potential to affect interpretation of data. Other recommendations and data gaps are discussed following this section.

1. ESTIMATION OF NATURAL STREAM FLOWS

As was discussed in previous sections, gaged flows represent current use and not natural stream flows. To better understand the impact of water rights allocations, the current use would need to be estimated and added back into gage flows to get a more accurate picture of natural flows. Then a comparison of these estimated natural flows and the water rights allocation could be achieved. There are two methods to do this, one is less expensive and is restricted to the period of record of the gage, and the other is more expensive and with calibration can encompass a much longer time frame as well as address land use changes (i.e. from agricultural or rural to urban).

- Method 1: Estimate actual use (see recommendation 2) on a monthly basis and add to the monthly flows for the period of record. An assumption would have to be made that the actual use for the period of record is similar to the actual use currently. Compare the estimate of natural flows to water rights allocation

(Cost: $20,000 to $30,000 not including current irrigation and crop inventory).

- Method 2: Develop a hydrologic model that can be calibrated to gaged flows incorporating the actual use. Simulation of natural flows over any period of record with the climate record availability is possible. The flow duration curves from the simulated time period can then be compared to the water rights allocation. (Cost: $75,000 to $100,000)

2. IMPROVE ESTIMATES OF ACTUAL IRRIGATION WATER USE

The extent of actual irrigation in the Lower Nisqually Basin is unknown. Assumptions in the Level 1 report were made from Agricultural Statistics for Pierce and Thurston Counties. The irrigation water rights represent the largest difference potentially between actual use and water rights entitlement. Therefore, it is a worthwhile effort to really understand what extent irrigation is occurring in the focus subbasins. To do this would entail:

1) A field inventory of crops grown in the basin and identified with particular parcels;

2) Interviews with farmers if they are willing (this is the key to the best possible product and the most difficult to obtain);

3) Discussions with the NRCS, Thurston and/or Pierce Conservation Districts, and the Farm Service Agency; and

4) Plot the irrigation water rights places of use and points of diversion.

The final product would be spatial displays and summary tables of the crops grown in the selected subbasin(s), identification of which ones are irrigated, whether or not the parcels have water rights associated with the irrigated parcels, and parcels that have water rights not being used. The latter is a case where water rights may potentially be transferred to other uses/points of diversion or retired. (Cost: $75,000 to $100,000).

3. MCALLISTER CREEK GROUNDWATER MODELING

The McAllister subbasin has potentially significant conflicts in water resource demands that require additional evaluation and data collection. We understand that additional data is being developed for the McAllister subbasin from watershed planning/groundwater modeling activities currently being completed by the Cities of Olympia and Lacey. Muck/Murray and the Yelm subbasins also have the potential for significant water resource conflicts; given the anticipated growth, development, increase in water use and potential for water quality degradation that is forecasted for these watersheds. The Toboton, Tanwax and Mashel subbasins all are anticipated to have low potential water resource conflicts based on the current and 20-year projected population growth data. The following actions are recommended:

- Perform a detailed evaluation of the groundwater flow models (CDM/AGI) developed for the McAllister and portions of the Yelm subbasins. Determine if the model(s) can be used to provide realistic approximations of groundwater/surface water interaction under specific groundwater use scenarios in the subbasins (McAllister/Yelm). This evaluation should be conducted in collaboration with regional purveyors and Ecology.

- Utilize the groundwater flow model(s) to assess potential stream/groundwater interaction for the various aquifers. If possible use the groundwater model(s) as a tool to assist in making regional water resource management decisions.

- Use the groundwater flow model(s) for evaluating potential water resource management options for future groundwater development such as stream flow augmentation, induced recharge, optimization of well placement and seasonal timing of pumping to reduce aquifer drawdown and stream flow depletion in the McAllister and Yelm subbasins.

- Complete a detailed evaluation of groundwater use in the Yelm and Muck/Murray subbasins. One of the goals of this evaluation would be to identify/quantify specific areas of high groundwater use.

- Evaluate the potential effect of these high groundwater use areas on the flow in nearby streams with seasonal flow problems. We anticipate that the groundwater flow model developed by others (AGI/CDM) for can be used to evaluate these specific areas in the Yelm subbasin. The potential impact of other high groundwater use areas located in the Muck/Murray subbasin could be evaluated using site-specific analytical modeling and/or numerical modeling, if necessary.

The cost of these analyses is estimated in the range of $10,000 to $50,000.

4. STREAM GAGES

The availability of long-term records for the Mashel and Ohop tributaries, and for most of the mainstem Nisqually River, allowed us to perform a relatively robust assessment of water availability for these areas. However, the extrapolation of the short-term record from Muck Creek to the remaining tributary sub-basins was one of the weak links in the Level I analysis. Estimation of water availability in the tributaries was further complicated by the different flow patterns that occur "up on the prairies" (i.e., significant discharge from the streams to the aquifer) versus down at the mouths of most tributaries, where significant discharge of water from the aquifer to the streams occur.

Continued data collection in some areas and added monitoring stations in other areas would substantially improve estimates of water availability and stream flow. The following is a prioritized list, from most important to least important, of recommendations for maintenance/development of the stream gage system in the lower Nisqually:

- **Maintain all currently active stream gages in the Lower Nisqually Basin**: The existing network of active stream gages should be maintained. Several (if not all) of these gages are currently maintained under the USGS Cooperative Program, under which the USGS provides up to 50 percent of the funds, and governments or other local entities provide the remainder.

- **Continue collecting stream flow data at the WDOE gage at RM 4.6 of the Nisqually River**: The WDOE stream gage that was installed in August 2000, provides critical missing information on stream flows in the lower section of the

Nisqually River. The short data set that is available suggests that stream flow is greater near the downstream end of the reach in certain months (i.e., that tributary and spring flow makes a significant contribution within the reach), while in other months the reach is a "losing" reach. Longer-term measurements at the WDOE site are needed to better-understand stream flow conditions in this reach.

- **Yelm Creek**: The Yelm Creek sub-basin has undergone significant development in the past decade, and will likely see more in the future. The lower one-mile of Yelm Creek is an important reach used by anadromous fish. No long-term stream flow records are available for this sub-basin. Significant errors in estimated water availability likely exist due to extrapolation of the short-term record from Muck Creek to the Yelm Creek sub-basin (i.e., the approach used in the Level I analysis). The presence of Crystal Springs at approximately RM 1.3 result in significantly different flow patterns at the mouth versus upstream. At least one permanent stream gage should be located on Yelm Creek (upstream of Crystal Springs), with an additional permanent or temporary gage (the intent of "temporary" gages is explained below) located near the mouth.

- **Muck Creek**: The Muck Creek portion of the Muck/Murray sub-basin has also undergone significant development in the past decade, and will likely see more in the future. Muck Creek is also an important tributary used by anadromous fish. The USGS gage located at approximately RM 6 has been discontinued, however, the existing record provides a good characterization of the "prairie" portion of the sub-basin. The presence of significant spring flow downstream of the gage location (e.g., Exeter Springs, RM 2.3) results in significantly different flow patterns at the mouth versus upstream. A permanent stream gage should be re-established at the former gage location near the town of Roy, with an additional permanent or temporary gage located near the mouth.

- **Powell, Murray, Toboton, Tanwax, and Horn Creeks**: All of these tributaries are important anadromous fish streams, however, development pressure has been lower, and will likely be lower in the future, than for Yelm and Muck Creeks. The USGS maintained a stream gage near the mouth of Tanwax Creek for a five-year period, but this gage is now discontinued. The recommended approach would be to reestablish a permanent gage on Tanwax Creek, and establish

temporary gages at the mouths of the remaining creeks. Additionally, Powell, Murray, and Toboton Creeks experience significant spring flow near there mouths, so temporary gages could also be located upstream of the spring flow reaches.

Permanent Gages

Permanent gages are defined here as gages that are intended to be maintained indefinitely, or at least for a period of ten years. It is recommended that permanent gages be established and maintained by the USGS their Cooperative Program. The fundamental characteristic of the Program is that government or local entities provide at least half the funds, but the USGS does most of the work. Having the USGS do the work results in consistent techniques of data collection and archiving, with the information stored in a common data base readily available to all. The cost for the USGS to maintain a gage will vary by location, but is approximately $5000 per year.

Temporary Gages

Temporary gages are defined here as gages that are intended to be maintained for relatively short time periods at a given location, and then moved to another site. The intent of these gages is to collect enough data to develop correlations with nearby permanent gages. For example, if a permanent gage were established in Yelm Creek upstream on the "prairie", a temporary gage at the mouth would provide short-term data to characterize flow inputs from springs. Once these correlations are developed the records from the permanent stations could be used to develop more accurate synthetic hydrographs for the temporary locations.

Establishment and maintenance of the temporary gages would be most cost-effective if performed by a local entity. Required equipment would be a current meter (the cheapest are approximately $700) to establish a stage-discharge relationship, and a device for each site to continuously-record stream stage. The most inexpensive device will cost approximately $800 (www.globalw.com/waterlvl.html).

5. INSTREAM FLOWS

Instream flows have been set for the mainstem. The instream flows were based on substantial study and no changes or review of those flows is recommended. In addition to the mainstem, the Mashel, Muck, Lower Ohop, and Tanwax all have substantial lengths of fish habitat. Habitat in the Lower Ohop is of poorer quality than the others. Instream flows have also been set for the Mashel River. These flows are larger than the 50% exceedance flow in August, meaning on average, the instream flow can be met less than half the time. A closer review of the methods used to develop these instream flows is recommended. No instream flow studies have been conducted in Muck, Lower Ohop, or Tanwax. Given that each of these streams contains large quantities of fish habitat, instream flow studies may be recommended. Instream flow studies will provide better information regarding the effects of withdrawals on fish habitat.

McAllister Creek is also closed to further withdrawals. No instream flow study has been conducted in this stream either. Given the high demand for water in the basin, an assessment of the relationship between flow and habitat conditions is recommended. This assessment should follow methods that are different than those normally applied to instream flow studies. The creek is influenced by tides over its entire length and a saltwater wedge extends most the way up the creek. Therefore, an alternative method to complete an analysis of the effects of stream flow on beneficial uses is recommended.

OTHER RECOMMENDATIONS

The above items are the activities most highly recommended by the analysis team. Other actions that may be considered include those listed in the following sections. Recommendations in this section are not prioritized. Headings relate to the general category of information the recommendation addresses.

GENERAL

- No digital data on soil conditions is available in sufficient detail to be used in hydrologic modeling for the portion of the watershed covered by the Pierce County soil survey (NRCS, 1979). In the event that further hydrologic modeling of peak and/or low flows is desired, this data should be digitized. The NRCS should be contacted to find out the digitizing status of this report.

- The Thurston County portion of the watershed lacks adequate existing land use GIS coverage. In the event that further hydrologic modeling of peak and/or low flows is desired, this information should be developed by Thurston County.

- The existing land use coverage for Pierce County does not make a distinction within lands classified as rural/residential as to what proportion of these areas are in a forest or agricultural use. In the event that further hydrologic modeling of peak and/or low flows is desired, this information should be developed. The easiest way would be to derive this information from aerial photos or satellite imagery.

- Establish precipitation gages in several locations within the subbasins (Water Systems). Record precipitation data on a daily bases.

- Organize the hydrogeologic/hydrologic data into an interactive database/GIS system that includes information on the following:

  - Well locations and approximate elevations
  - Well depth
  - Static water level elevations
  - Stratigraphy
  - Well yield
  - Well use
  - Water rights
  - Precipitation
  - Stream flow
  - Water quality

  The database could be used to monitor the effect of changing land/water use in the subbasins on the surface water and groundwater systems and to evaluate the effectiveness of water resources management options.

SURFACE WATER

- The primary recommendations regarding surface water are addressed in the priority recommendations above.

- The stream flow trend analysis was limited by the availability of long-term streamflow records. Given the short-term nature of the data set, and the many years that would be required to obtain adequate data for a more robust analysis, the appropriate action is to undertake further hydrologic modeling to assess the effects of other climatic variables and land use activities.

GROUNDWATER

- The primary recommendations regarding groundwater are addressed in the priority recommendations above.

- Develop a system/agreement to allow the compilation of current and future hydrogeologic data for the subbasins in collaboration with regional water purveyors and other affected stakeholders.

- Compile current and future water use estimates developed above into projected estimates of groundwater pumping for selected watersheds for various water-use categories.

WATER QUALITY

In terms of water quality the Nisqually River Basin is in an enviable position. Generally, the water quality is quite good especially in the mainstem. In addition, the series of water quality studies and investigations performed by the Nisqually Indian Tribe are excellent, and provide a fairly comprehensive framework for future evaluations. Although more could be done with the existing data sets, generally there are no glaring groundwater quality problems in the Basin that would justify further detailed analysis.

There is much more information that can be "mined" from these studies. The following four items are the highest in priority for future evaluations. Additional data gaps and monitoring recommendations are provided in the section on "Additional Data Gaps", following this section.

- One of the most effective means of evaluating water quality condition and pollutant contribution is through pollutant loading and yield analysis.

- Although comparison to water quality criteria can be informative, criteria exceedance needs to be evaluated against natural conditions and assessed in combination with other tools to set priorities. For example, those stream stations that are strongly influenced by lakes or wetlands, and exceed dissolved oxygen and temperature criteria, should be assessed against the natural condition or expectation. A preliminary evaluation of this could be completed at an estimated cost of $2500.

- Nitrate has been identified as being elevated in localized areas. It may be beneficial to analyze the WDOH data set at a more detailed level. The data should be divided by surface water subbasin and also by well depth to determine the subbasins where the near surface groundwater may be being impacted by land use.

- Subbasins that have little or no water quality data (e.g. Kreger Creek) should be considered for monitoring to determine baseline conditions.

FISH AND FISH HABITAT

- Virtually nothing is known about the presence of bull trout. If they are present, nothing is known about their current abundance, distribution, or relative "health" of the population. Surveys to determine the presence or absence of the species are recommended. If found to be present, additional surveys to determine the abundance and distribution are recommended. Longer term monitoring could also be conducted to determine trends in the populations over time.

- Instream flow recommendations are covered in the primary recommendations above.

WATER RIGHTS

- There are many errors in the WRATS database. There are likely several water rights that belong in this WRIA that plot in other locations. For the purposes of this analysis, we attempted to eliminate water rights that plotted in the WRIA but belong elsewhere. We did not screen the WRATS database for rights that plot in other basins but belong in this WRIA. In other basins, some water rights were also found on paper that were not included in the WRATS database. It is

unknown whether such a situation also exists for rights in WRIA 11. Additionally, certain fields in the WRATS tables have been found blank, such as allocated amounts and locations. The WRATS database should be corrected.

HYDROLOGICAL EFFECTS OF DEVELOPMENT (IN ADDITION TO WATER USE)

- Preliminary studies suggest that road drainage networks may be negatively impacting low flows in the Mashel sub-basin. The data, however, is not conclusive. Evaluate the effects of road drainage networks on stream flows in the Mashel sub-basin using a spatially distributed, physically based model.

- No information is available on the potential impacts of urbanization assuming full buildout (and the resultant increase in impervious area) on streamflows in the watershed. Potential urbanization effects should be evaluated in a two-step approach:

  - Prioritize sub-watersheds (true watersheds, not the subbasins used in the level I assessment) for further analysis based on the resulting population density assuming full buildout under current zoning.

  - Evaluate the effects of urbanization using stream flow modeling techniques that incorporate all relevant physical changes associated with urbanization (e.g., increased impervious area, loss of wetlands, changes in vegetation, etc).

- No quantitative evaluation has been performed in the watershed on the effects associated with loss of floodplain and wetland storage on stream flows. Possible effects associated with the loss of floodplain/ wetland storage on stream flow should be evaluated in a two-step approach:

  - Map the extent of historic floodplains and wetlands, and human-caused disturbances affecting these features (i.e., dikes, levees, wetland disturbance, etc).

  - Evaluate the effects of storage loss using stream flow modeling techniques.

- The changes in stream flow associated with changes in canopy interception and/or evapotranspiration as a result of land clearing have not been evaluated. Possible effects associated with changes in canopy should be evaluated in a two-step approach:

  - Estimate historical canopy conditions using, for example, potential vegetation descriptions of EPA level IV ecoregions. Evaluate current canopy conditions using aerial photography of satellite imagery. Prioritize sub-watersheds for further study based on relative differences between potential and current conditions.

  - Evaluate the effects of canopy changes on streamflows using stream flow modeling techniques (e.g., HSPF, DHSVM).

OTHER DATA GAPS

FISH AND FISH HABITAT

- The status of several salmon stocks in the Nisqually River is currently unknown. These include fall chinook, coho, and sockeye. The magnitude of adult hatchery fish that contribute to the spawning coho and chinook populations has not been determined. There is uncertainty regarding whether sockeye identified in the basin actually represent a viable population or are just strays. There is also relatively little information on bull trout in the basin (see above recommendations regarding bull trout).

- Little is known about non-salmonid fish species present in the basin.

- The effectiveness of the fish ladder on Beaver Creek in the Mashel basin is unknown.

- There is limited data regarding fish habitat conditions in Red Salmon Creek in the Muck/Murray subbasin.

- Thick growth of invasive reed canary grass has been identified as a problem in muck Creek although specific areas of concern need to be identified.

- There is no quantitative fish habitat data for Murray Creek.

- Sources of sediment in Murray Creek and causes of documented increased channel migration have not been identified.

- Additional investigation is warranted to understand the impact of docks (overwater structures) in Tanwax Lake on fish populations.

- Beaver dams have been implicated in the limitation of upstream migration of fish in several streams. It is uncertain how well this limitation is documented.

- There is limited quantitative data on habitat conditions in Yelm Creek. There is no data on substrate but there is an unverified concern about fines.

- There is an unverified concern regarding water temperature in Powell Creek.

- A comprehensive inventory of culverts on private and country roads that are impassable to resident fish species has not been completed.

WATER QUALITY

- A routine monitoring program that consists of a selection of "key" stations to assess long-term trends and a system of rotating between subbasins would be beneficial for long-term tracking.

- Storm event studies and pollutant tracking efforts should be considered in priority (high pollutant yield or high development rate) subbasins.

- Enterococci bacteria should be included in future studies to allow evaluation against new water quality criteria.

- No fecal coliform bacteria data were available for Murray Creek.

- The one summer measurement below the outlet of the lake on Tanwax Creek indicated extremely low oxygen levels. This should be verified with additional measurements.

GROUNDWATER

- Detailed comprehensive, regional hydrogeologic studies have not been completed in the Tanwax/Kreger/Ohop, Mashel, and Toboton/Powell/Lackamas subbasins to date. It is likely the conceptual hydrogeologic model presented by Drost and others (1999) is reasonably valid for areas that are underlain by a substantial thickness unconsolidated glacial and non-glacial sediments such as portions of the Tanwax/Kreger/Ohop and Toboton/Powell/Lackamas subbasins. However, large portions of the Toboton/Powel/Lackamas, Tanwax/Kreger/Ohop, and Mashel subbasins are underlain by bedrock and many of the geohydrologic units described by Drost (1999) might not be present in these areas.

- Locations of these wells are approximate and based on information presented on water well reports that are often in error.

WATER RIGHTS

- The awarded water rights that are found in the WRATS database were assumed to represent current use. It is likely that numerous water rights on the books have not been used for years. A more detailed analysis of water rights' places of use would need to be mapped and compared to parcel maps from the assessors' databases to understand the extent of those unused rights.

- Total water rights for commercial use in the WRIA were small. Estimates could be refined through further investigation into commercial use within public water systems to attain actual use estimates of this category of service. Since the total rights for this use are small, the refined numbers are unlikely to have a significant effect on planning activities.

- The WDOH maintains a database of all the public water systems in the state including information such as the source location (to the nearest quarter-quarter section), the population served by each system, and the number of residential and non-residential connections. The location information of many of the systems in the database is missing or incorrect. For the purposes of this assessment, the entire state was

searched for public water systems; therefore the incorrect information did not significantly affect this assessment. The database should, however, be corrected.